Wind Energy

Source of Wind Energy

Where does Wind Energy come From?

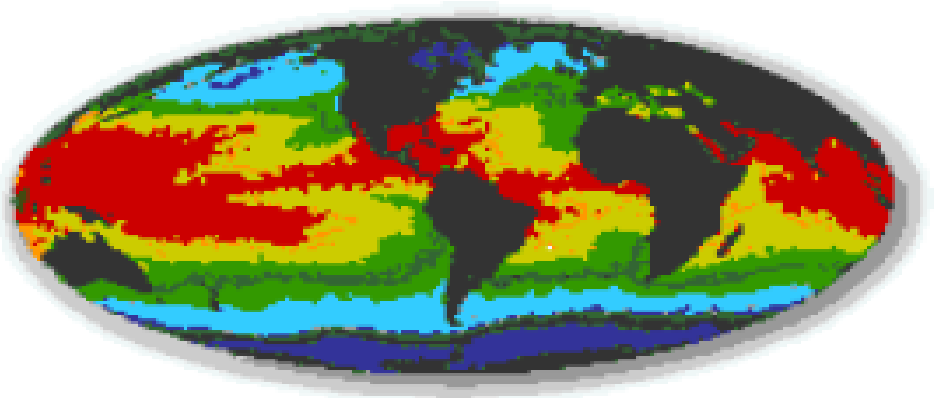
All renewable energy (except tidal and geothermal power), and even the energy in fossil fuels, ultimately comes from the sun. The sun radiates 174,423,000,000,000 kilowatt hours of energy to the earth per hour. In other words, the earth receives 1.74 x 10^{17} watts of power . [1)]

About 1 to 2 per cent of the energy coming from the sun is converted into wind energy. That is about 50 to 100 times more than the energy converted into biomass by all plants on earth. [2)]

Wind generation

Temperature Differences Drive Air Circulation

The regions around equator, at 0° latitude are heated more by the sun than the rest of the globe. These hot areas are indicated in the warm colours, red, orange and yellow in this infrared picture of sea surface temperatures (taken from a NASA satellite, NOAA-7 in July 1984).

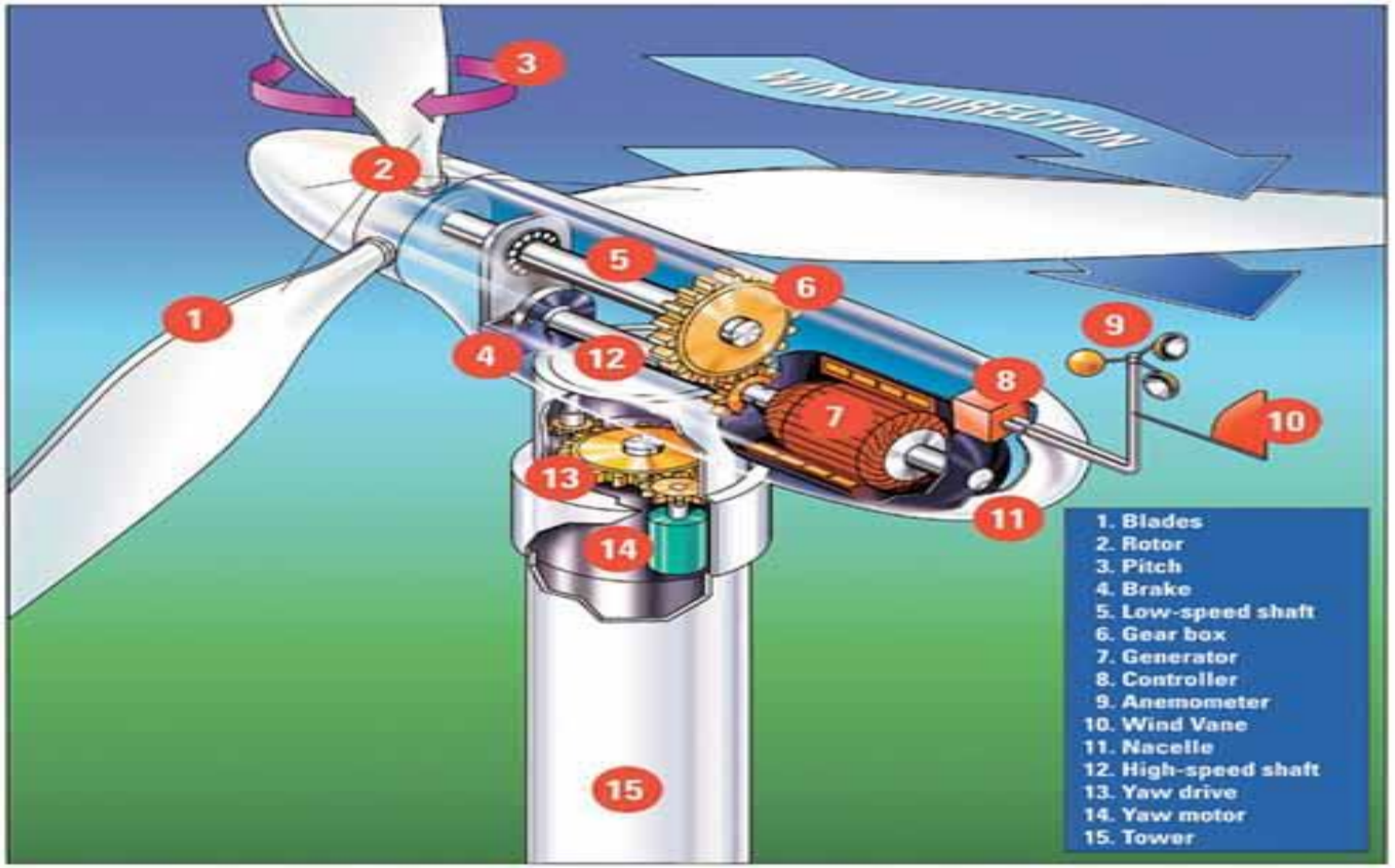


Hot air is lighter than cold air and will rise into the sky until it reaches approximately 10 km (6 miles) altitude and will spread to the North and the South. If the globe did not rotate, the air would simply arrive at the North Pole and the South Pole, sink down, and return to the equator.

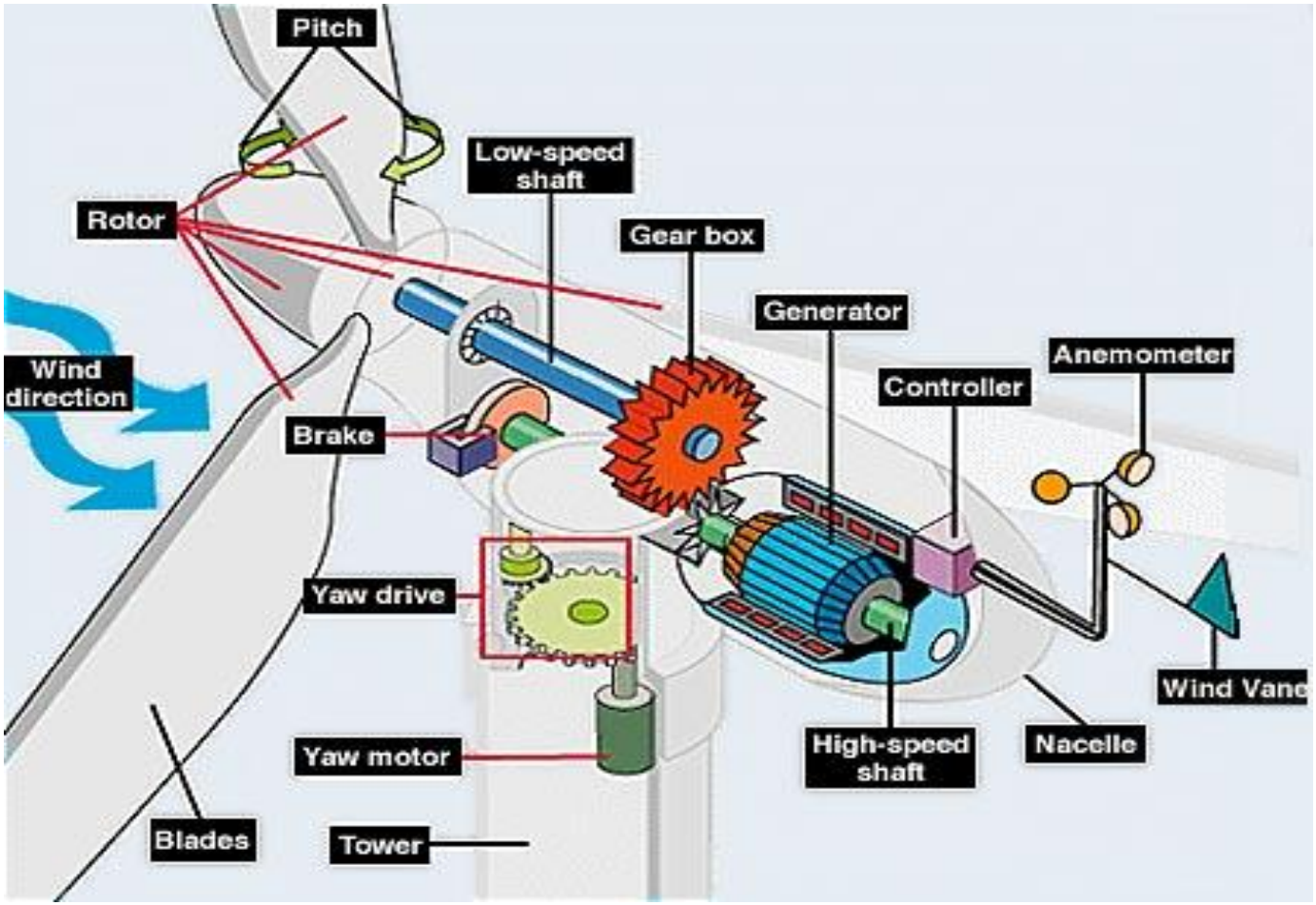
Wind ….

- **Wind power** is the conversion of wind energy into useful form, such as electricity, using wind turbines.
- In windmills, wind energy is directly used to crush grain or to pump water. At the end of 2007, worldwide capacity of wind-powered generators was 94.1 gigawatts.
- Although wind currently produces just over 1% of world-wide electricity use,it accounts for approximately 19% of electricity production in Denmark, 9% in Spain and Portugal, and 6% in Germany and the Republic of Ireland (2007 data). Globally, wind power generation increased more than fivefold between 2000 and 2007.
- Wind power is produced in large scale wind farms connected to electrical grids, as well as in individual turbines for providing electricity to isolated locations.
- Wind energy is plentiful, renewable, widely distributed, clean, and reduces greenhouse gas emissions when it displaces fossil-fuel-derived electricity.

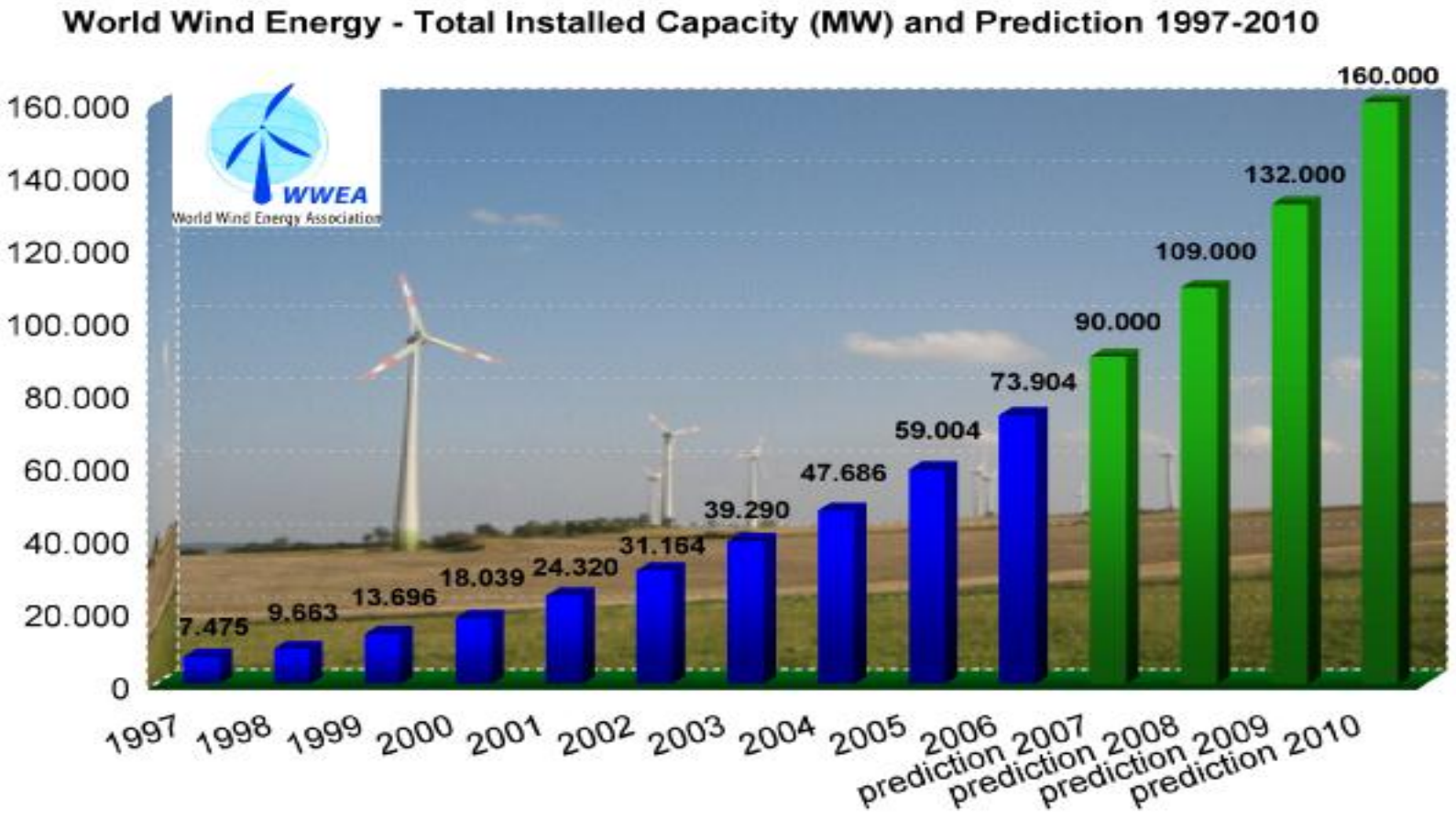
Wind turbine parts



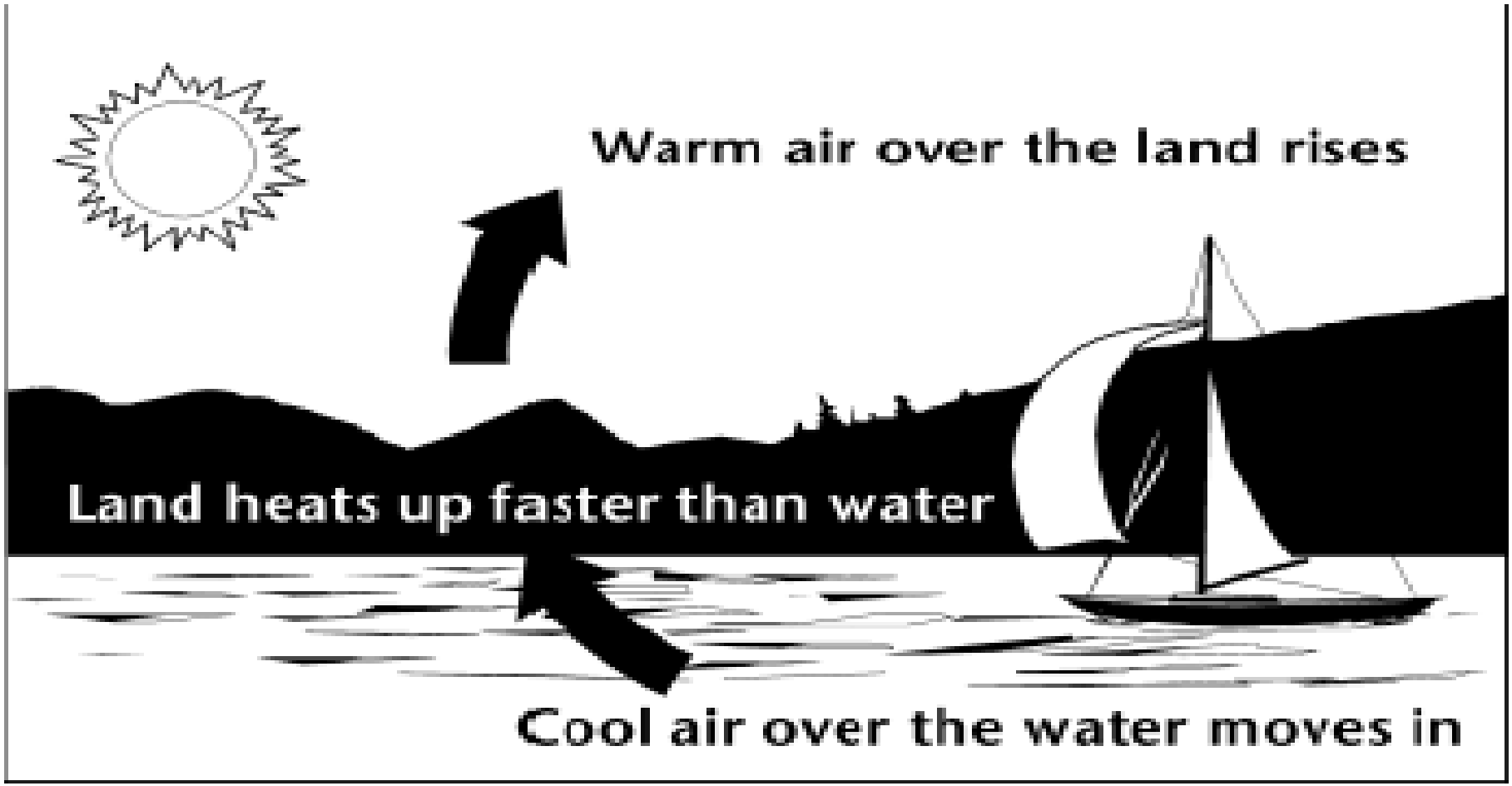
Wind turbine parts



World's Wind Installed Capacity



Where does Wind Energy come From?



Wind Energy

- Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates.

- During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air cools more rapidly over land than over water.

- In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles.

- Today, wind energy is mainly used to generate electricity. Wind is called a renewable energy source because the wind will blow as long as the sun shines.

The History of Wind

- Since ancient times, people have harnessed the winds energy.
- Over 5,000 years ago, the ancient Egyptians used wind to sail ships on the Nile River.
- Later, people built windmills to grind wheat and other grains. The earliest known windmills were in Persia (Iran).
- As late as the 1920s, Americans used small windmills to generate electricity in rural areas without electric service.
- In the early 1980s wind energy really took off in California, partly because of state policies that encouraged renewable energy sources.

HOW WIND MACHINES WORK

- wind machines use blades to collect the wind's kinetic energy.
- Windmills work because they slow down the speed of the wind.
- The blades are connected to a drive shaft that turns an electric generator to produce electricity.

TYPES OF WIND MACHINES

- There are two types of wind machines (turbines) used today based on the direction of the rotating shaft (axis)

1. horizontal–axis wind machines
2. vertical-axis wind machines

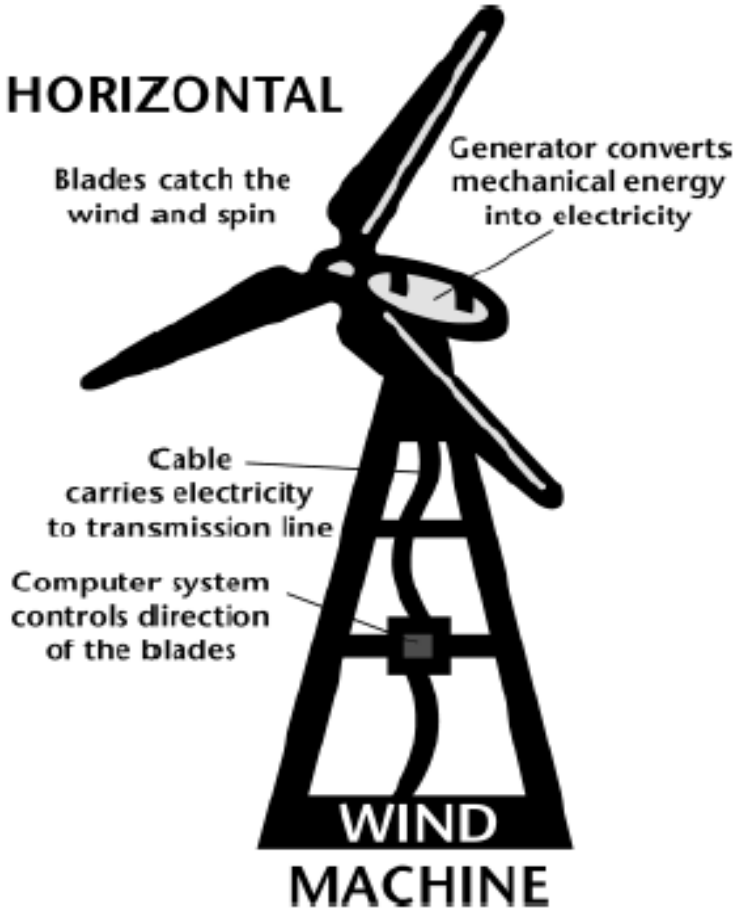
- The size of wind machines varies widely. Small turbines used to power a single home or business may have a capacity of less than 100 kilowatts.

- Some large commercial sized turbines may have a capacity of 5 million watts, or 5 megawatts.

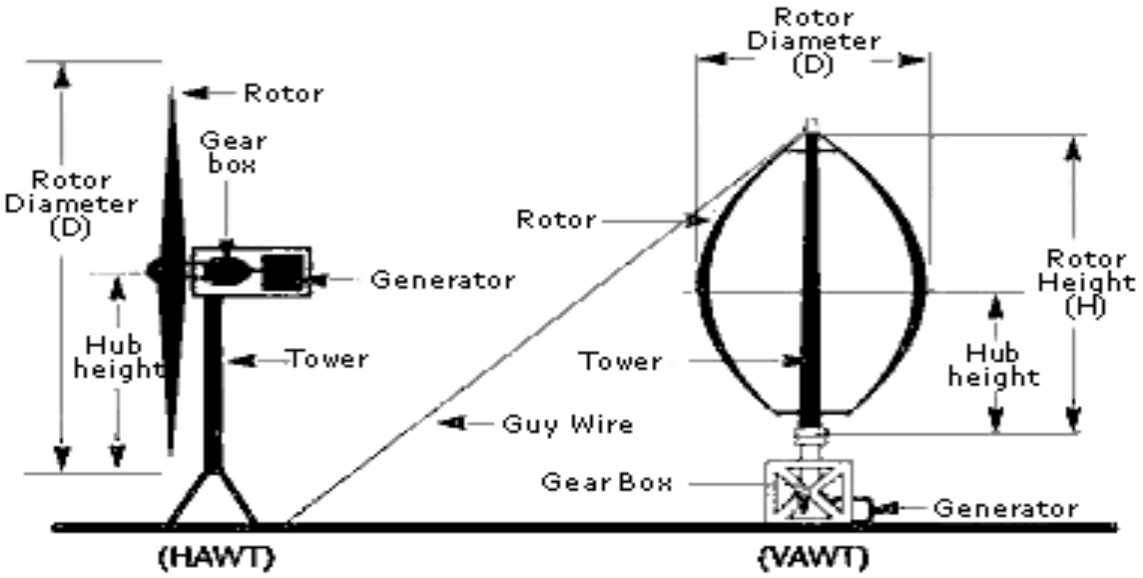
- Larger turbines are often grouped together into **wind farms** that provide power to the electrical grid.

Horizontal-axis

- Most wind machines being used today are the horizontal-axis type.
- Horizontal-axis wind machines have blades like airplane propellers.
- A typical horizontal wind machine stands as tall as a 20-story building and has three blades that span 200 feet across.



Horizontal and Vertical Turbines



Vertical-axis

- Vertical–axis wind machines have blades that go from top to bottom and the most common type (Darrieus wind turbine)

- Vertical-axis wind machines make up only a very small percent of the wind machines used today.

Wind Site Requisites

HOME

INDIAN WIND TURBINE MANUFACTURERS' ASSOCIATION

FEEDBACK

Wind Site Requisites

Area required per Wind Turbine = 5Acres (approx)

- Grid availability.
- Accessability for commisioning.
- Strong terrain / soil for proper foundation / civil work
- Favourable environmental condition to prevent corrosion & not prone to cyclone.

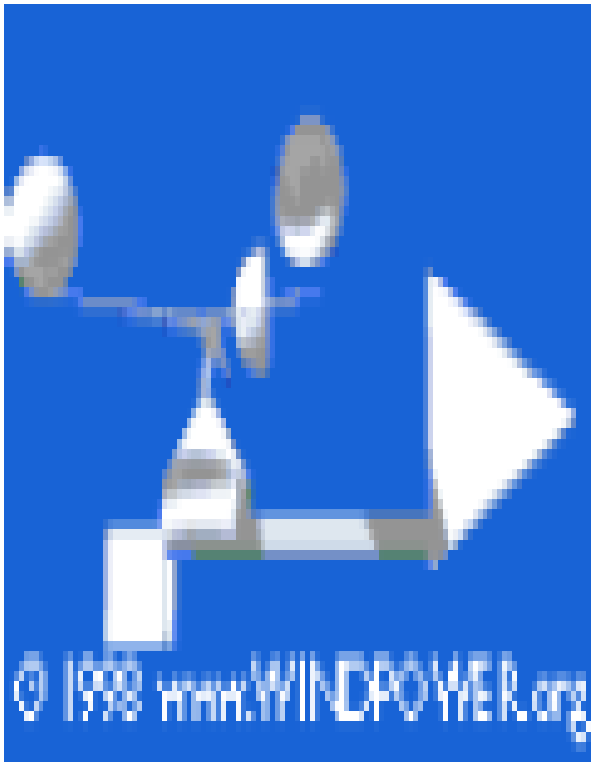
Go to Top

WIND AND THE ENVIRONMENT

- In the 1970s, oil shortages pushed the development of alternative energy sources.
- In the 1990s, the push came from a renewed concern for the environment in response to scientific studies indicating potential changes to the global climate if the use of fossil fuels continues to increase.
- Wind energy offers a viable, economical alternative to conventional power plants in many areas.
- Wind is a clean fuel; wind farms produce no air or water pollution because no fuel is burned.
- The most serious environmental drawbacks to wind machines may be their negative effect on wild bird populations and the visual impact on the landscape.

Wind Speed Measurement: Anemometers

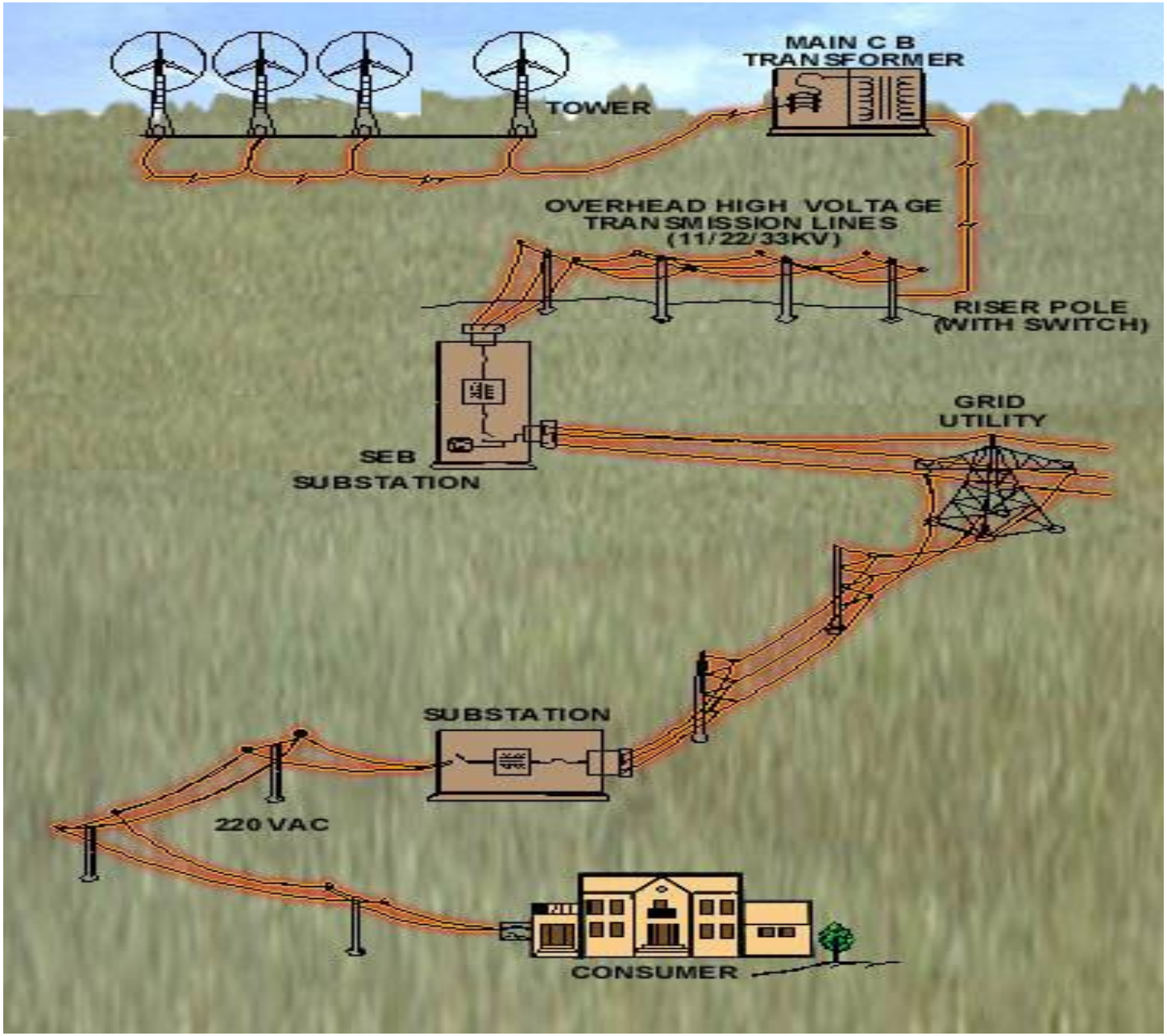
- The measurement of wind speeds is usually done using a cup anemometer.
- The cup anemometer has a vertical axis and three cups which capture the wind.
- The number of revolutions per minute is registered electronically.



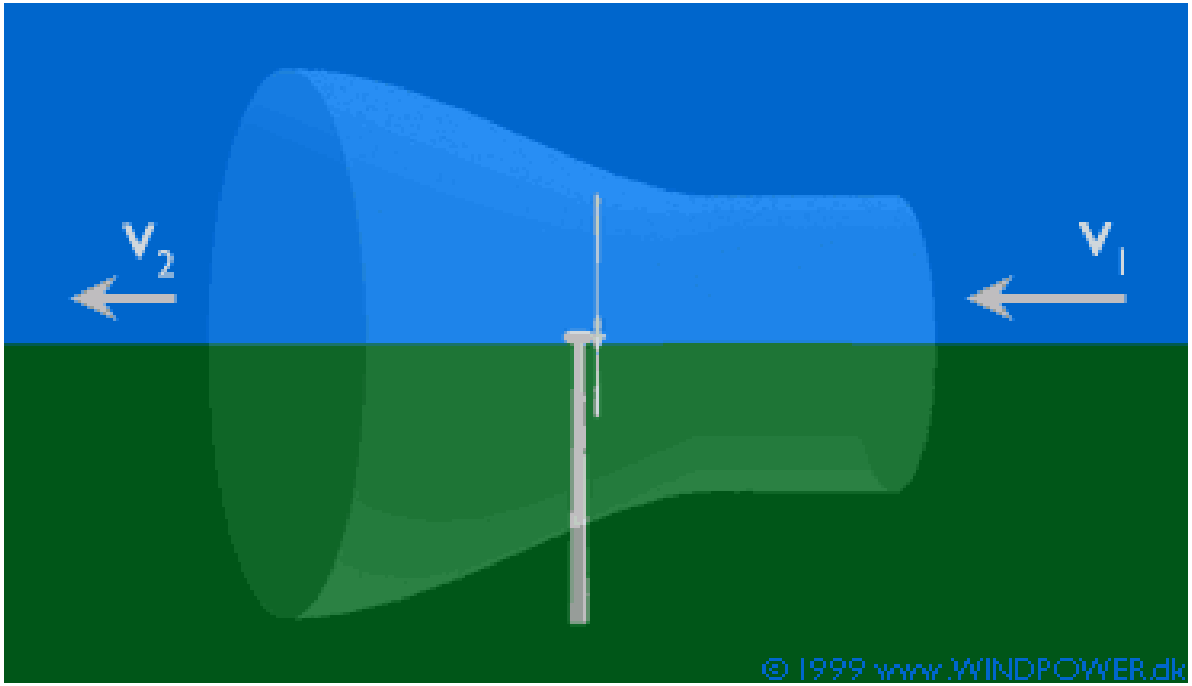
Wind Speed Measurement in Practice

- The best way of measuring wind speeds at a prospective wind turbine site is to fit an anemometer to the top of a mast which has the same height as the expected hub height of the wind turbine to be used.

- This way one avoids the uncertainty involved in recalculating the wind speeds to a different height.


MAIN C B
TRANSFORMER
TOWER
OVERHEAD HIGH VOLTAGE
TRANSMISSION LINES
(11/22/33KV)
RISER POLE
(WITH SWITCH)
GRID
UTILITY
SEB
SUBSTATION
SUBSTATION
220 VAC
CONSUMER

Proof of Betz' Law



Proof of Betz' Law

- Let us make the reasonable assumption that the average wind speed through the rotor area is the average of the undisturbed wind speed before the wind turbine, v 1 , and the wind speed after the passage through the rotor plane, v 2 , i.e. (v 1 +v 2)/2. (Betz offers a proof of this).

- The mass of the air streaming through the rotor during one second is

$$m = F (v_1 + v_2)/2$$

where m is the mass per second, is the density of air, F is the swept rotor area and $[(v_1 + v_2)/2]$ is the average wind speed through the rotor area. The power extracted from the wind by the rotor is equal to the mass times the drop in the wind speed squared (according to Newton's second law):

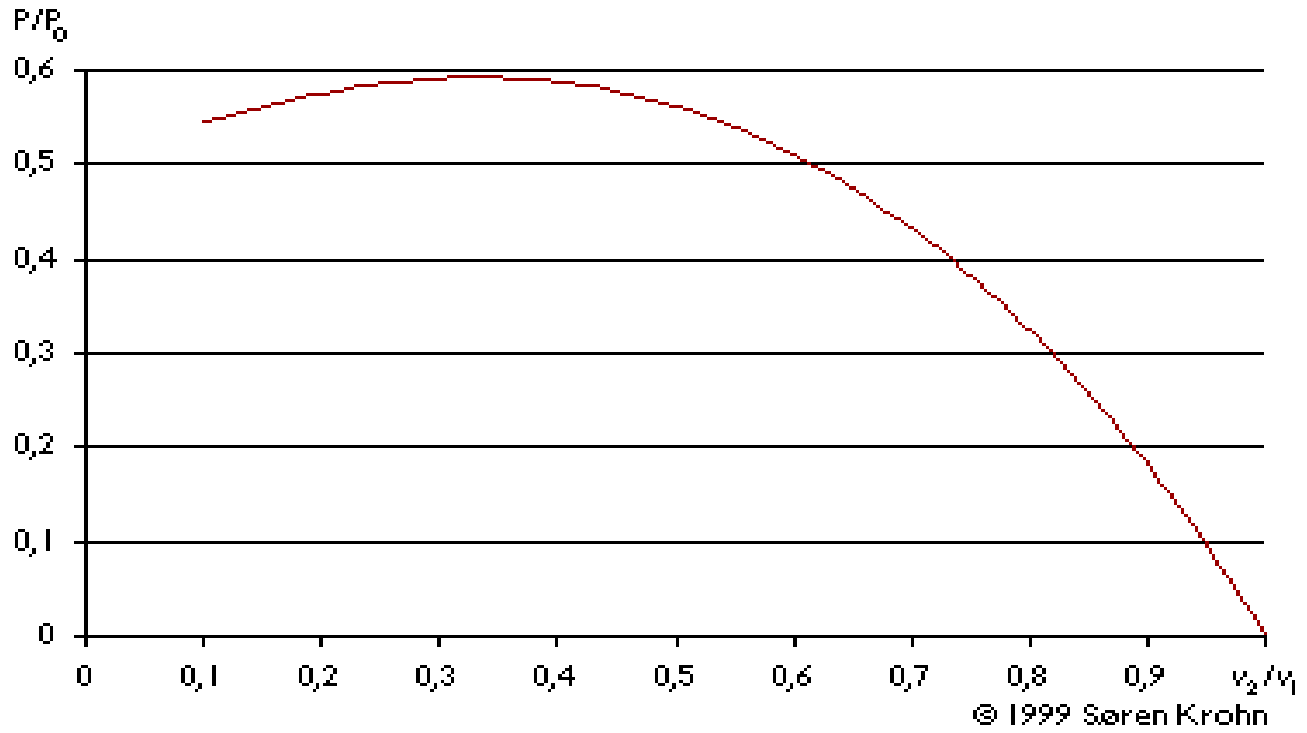
Proof of Betz' Law

- P = (1/2) m (v 1 2 - v 2 2)
- Substituting m into this expression from the first equation we get the following expression for the power extracted from the wind:
- P = (/4) (v 1 2 - v 2 2) (v 1 +v 2) F

Proof of Betz' Law

- Now, let us compare our result with the total power in the undisturbed wind streaming through exactly the same area F, with no rotor blocking the wind. We call this power P 0 :
- P 0 = (/2) v 1 3 F
- The ratio between the power we extract from the wind and the power in the undisturbed wind is then:
- (P/P 0) = (1/2) (1 - (v 2 / v 1) 2) (1 + (v 2 / v 1))

Proof of Betz' Law

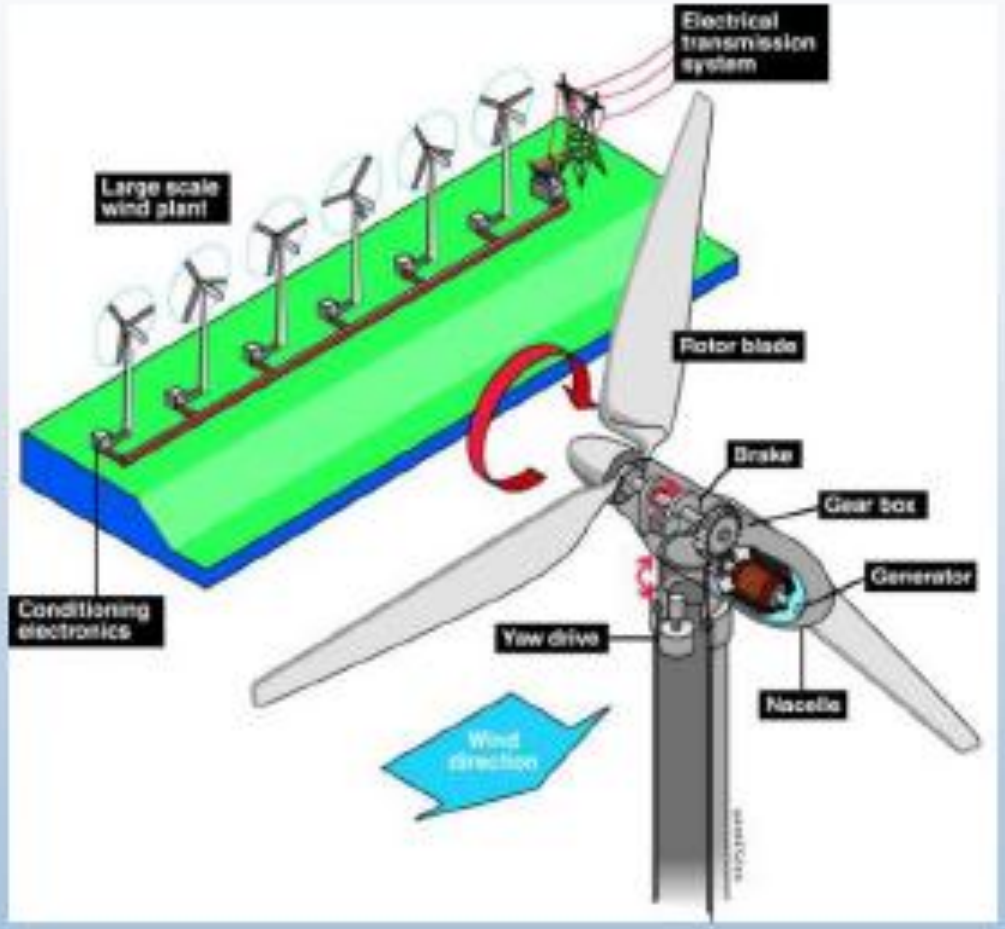


Proof of Betz' Law

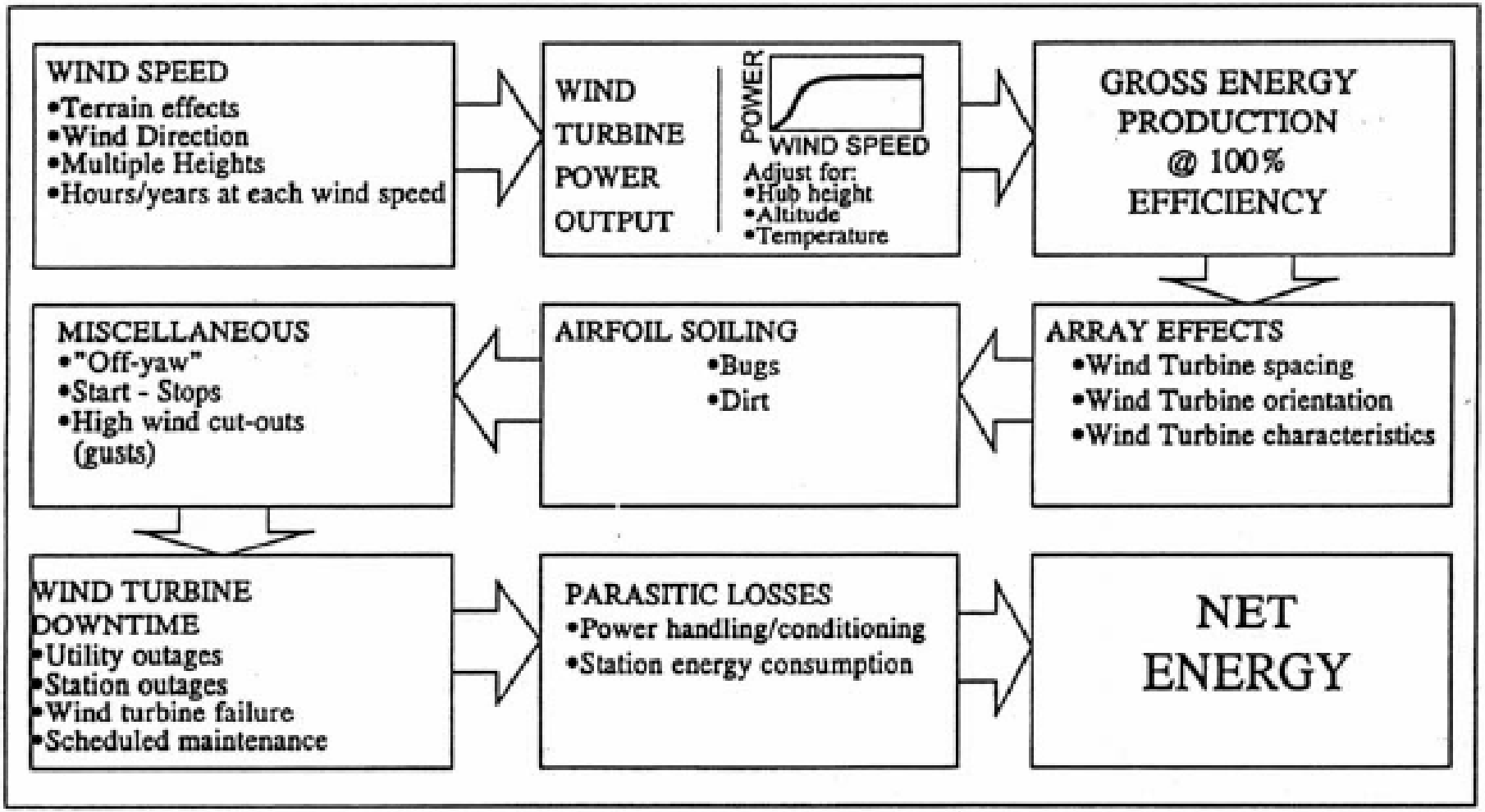
We can see that the function reaches its maximum for v 2 /v 1 = 1/3, and that the maximum value for the power extracted from the wind is 0,59 or 16/27 of the total power in the wind.

Wind Energy Technology

At it's simplest, the wind turns the turbine's blades, which spin a shaft connected to a generator that makes electricity. Large turbines can be grouped together to form a wind power plant, which feeds power to the electrical transmission system.



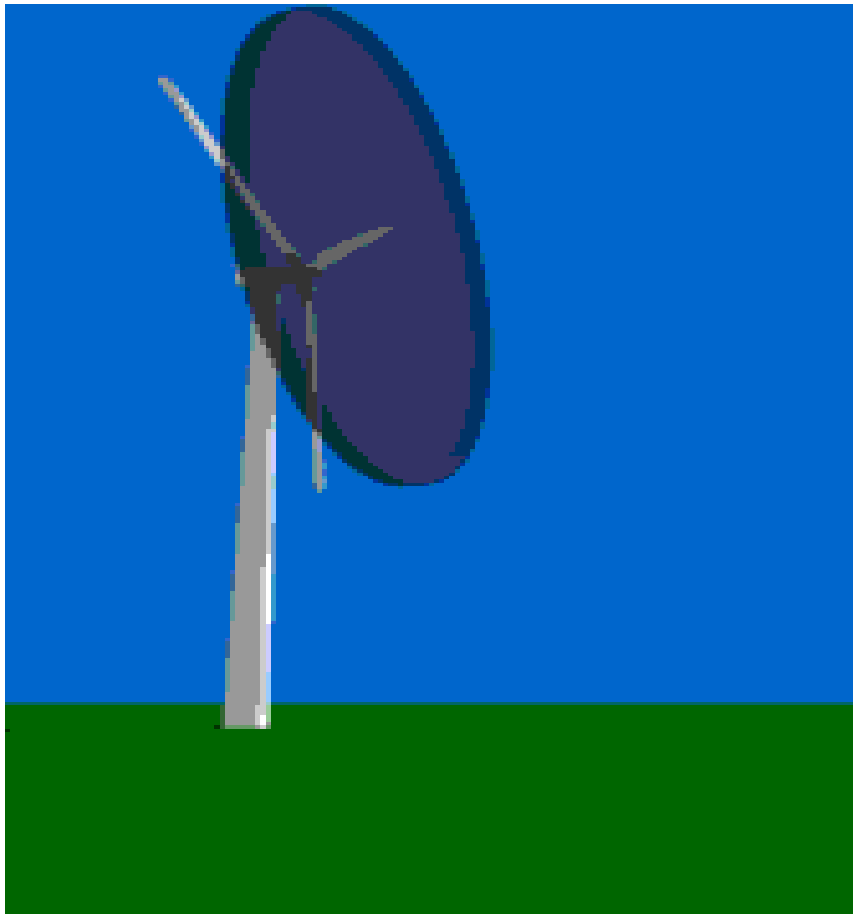
Net Energy Calculations



The Energy in the Wind: Air Density and Rotor Area

- A wind turbine obtains its power input by converting the force of the wind into a torque (turning force) acting on the rotor blades.

- The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed.



Power of the Wind Formula

The power of the wind passing perpendicularly through a circular area is:

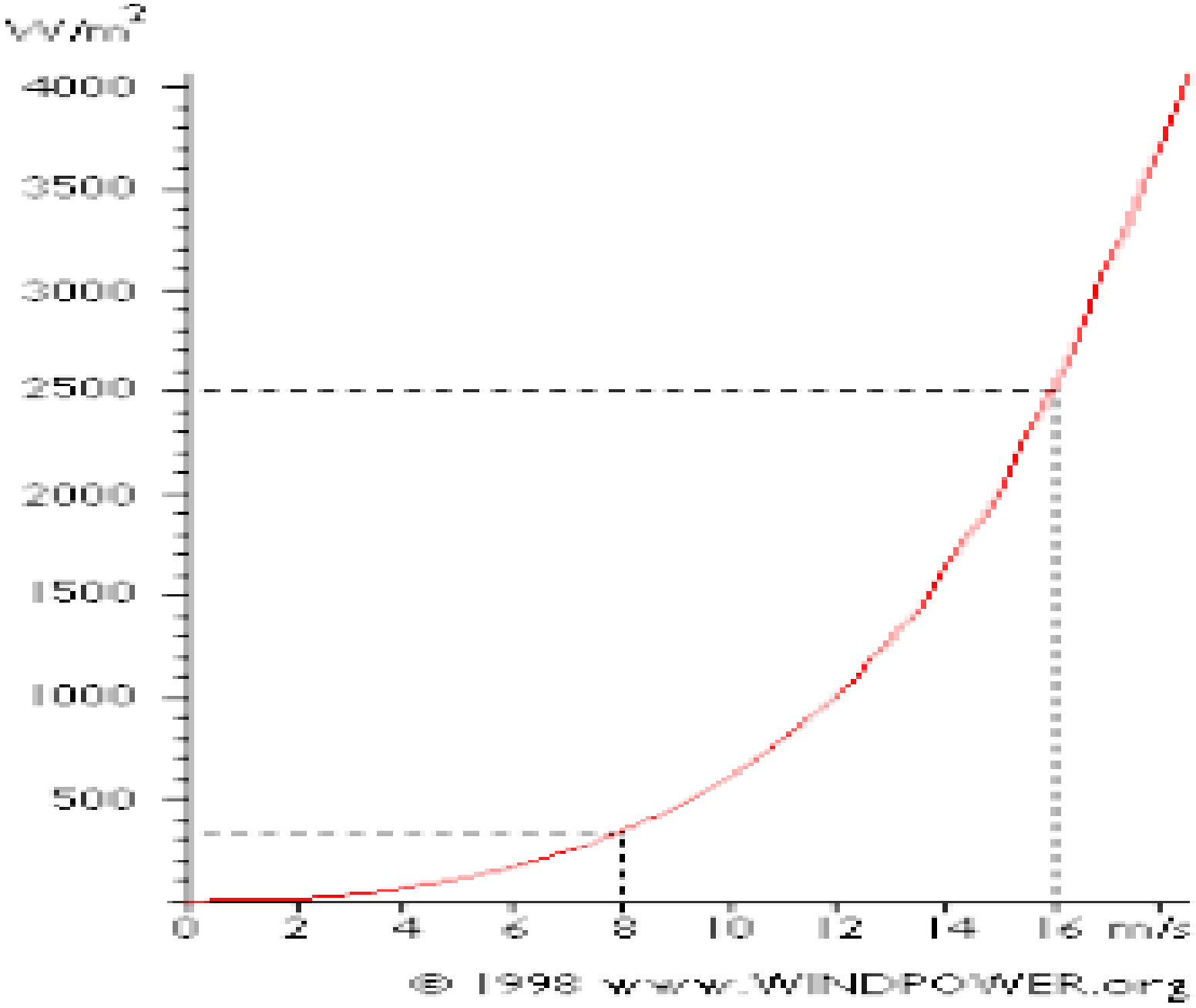
$P = 1/2 \rho v^3 \pi r^2$

Where P = the power of the wind measured in W (Watt).

ρ = (rho) = the density of dry air = 1.225 measured in kg/m 3 (kilogrammes per cubic metre, at average atmospheric pressure at sea level at 15° C).

v = the velocity of the wind measured in m/s (metres per second). π = (pi) = 3.1415926535...

r = the radius (i.e. half the diameter) of the rotor measured in m (metres).


W/m²
4000
3500
3000
2500
2000
1500
1000
500
0
2
4
6
8
10
12
14
16
m/s
© 1998 www.WINDPOWER.org

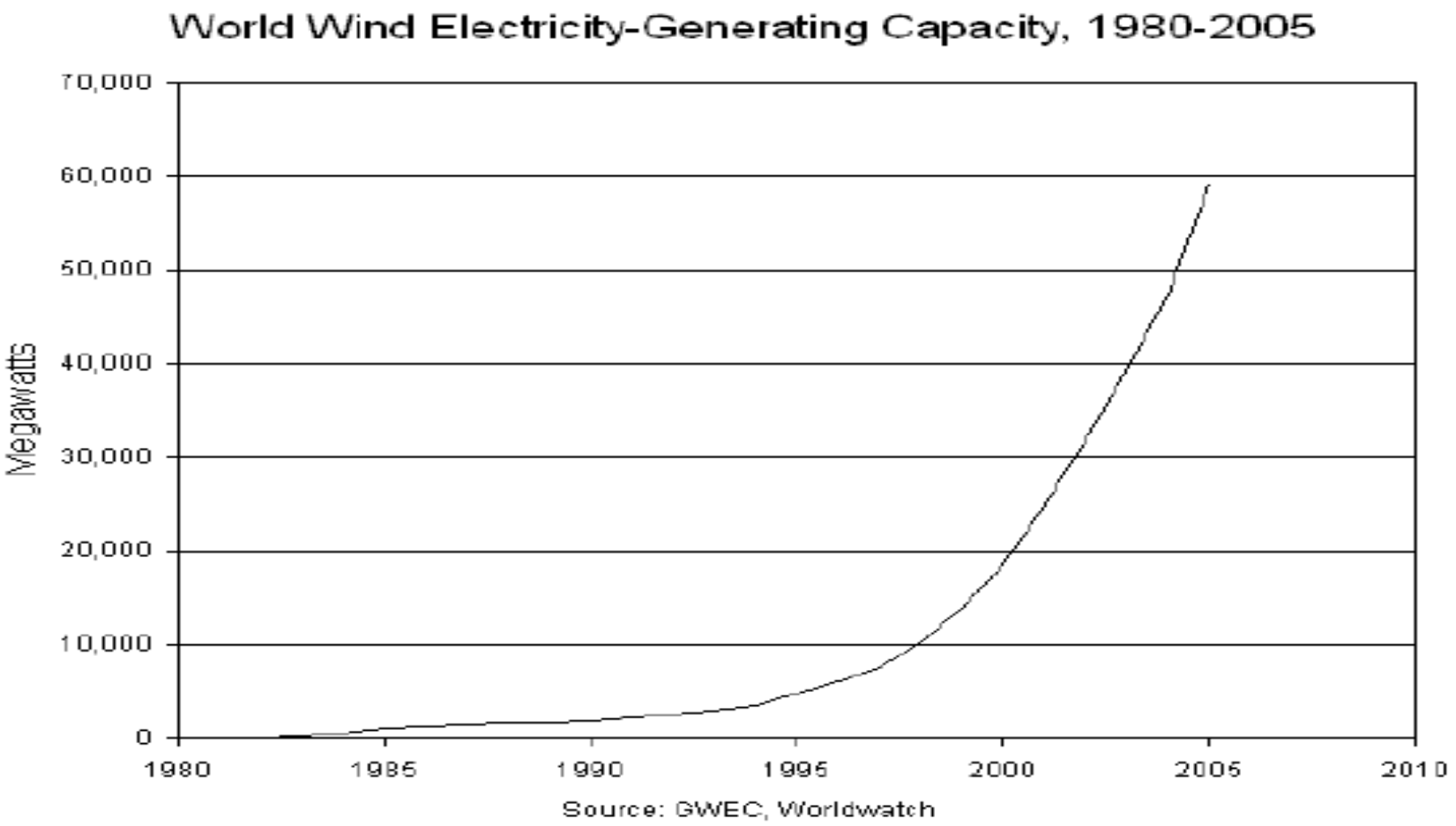
Wind Power generation System

- Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic (solar cell) system. For utility-scale sources of wind energy, a large number of wind turbines are usually built close together to form a *wind plant*. Several electricity providers today use wind plants to supply power to their customers.

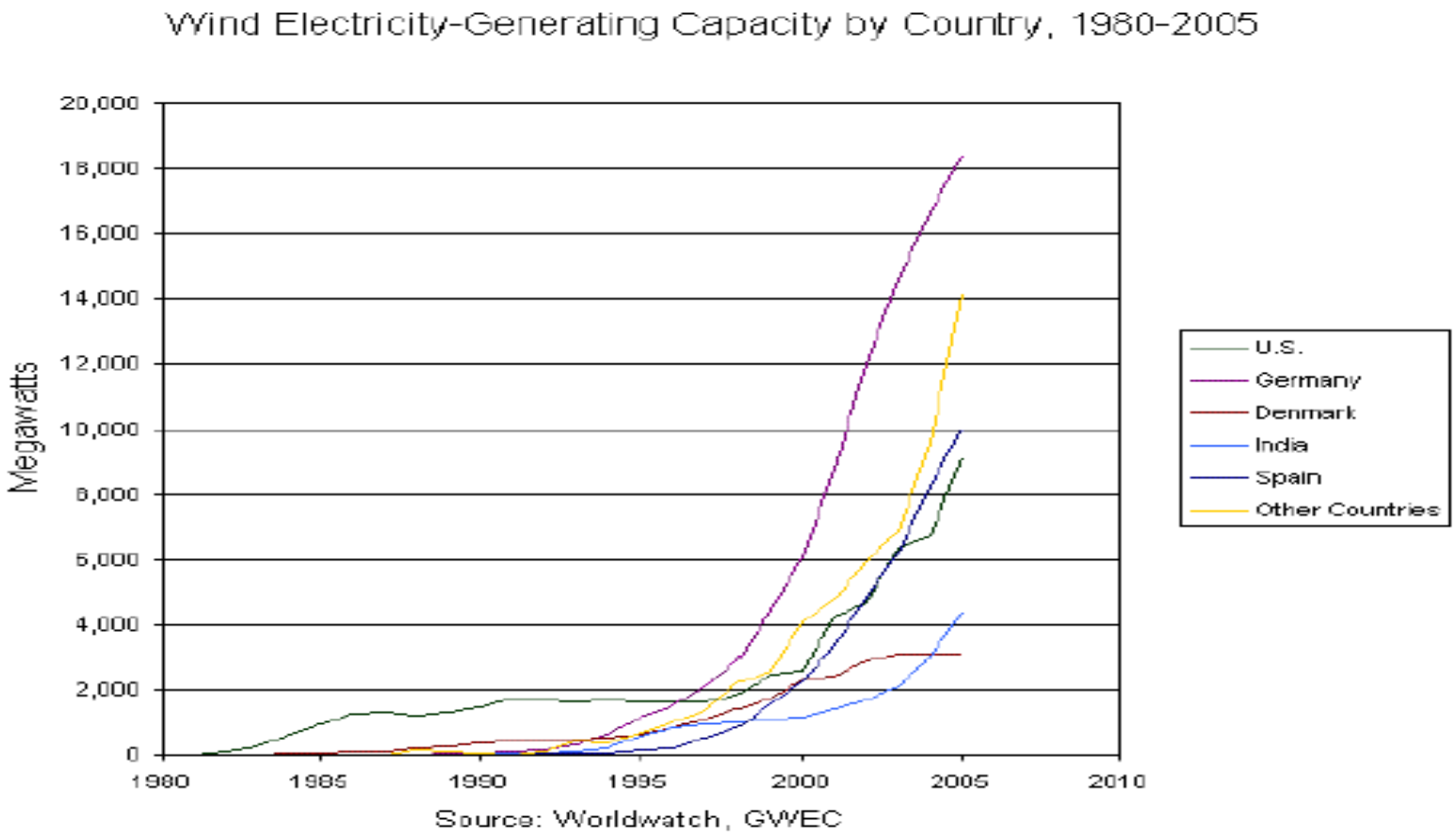
- Stand-alone wind turbines are typically used for water pumping or communications. However, homeowners, farmers, and ranchers in windy areas can also use wind turbines as a way to cut their electric bills.

- Small wind systems also have potential as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.

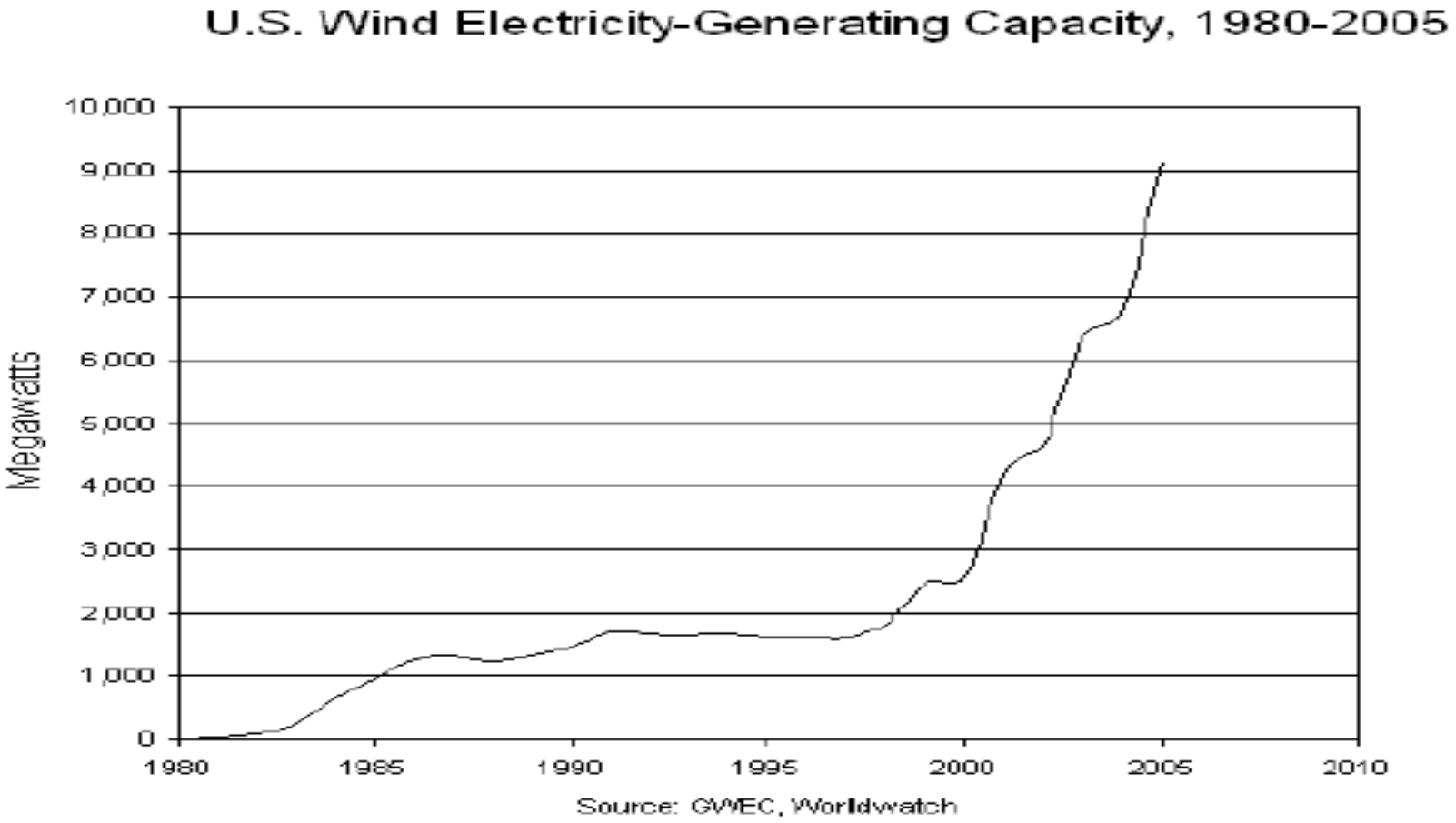
World Wind Scenario



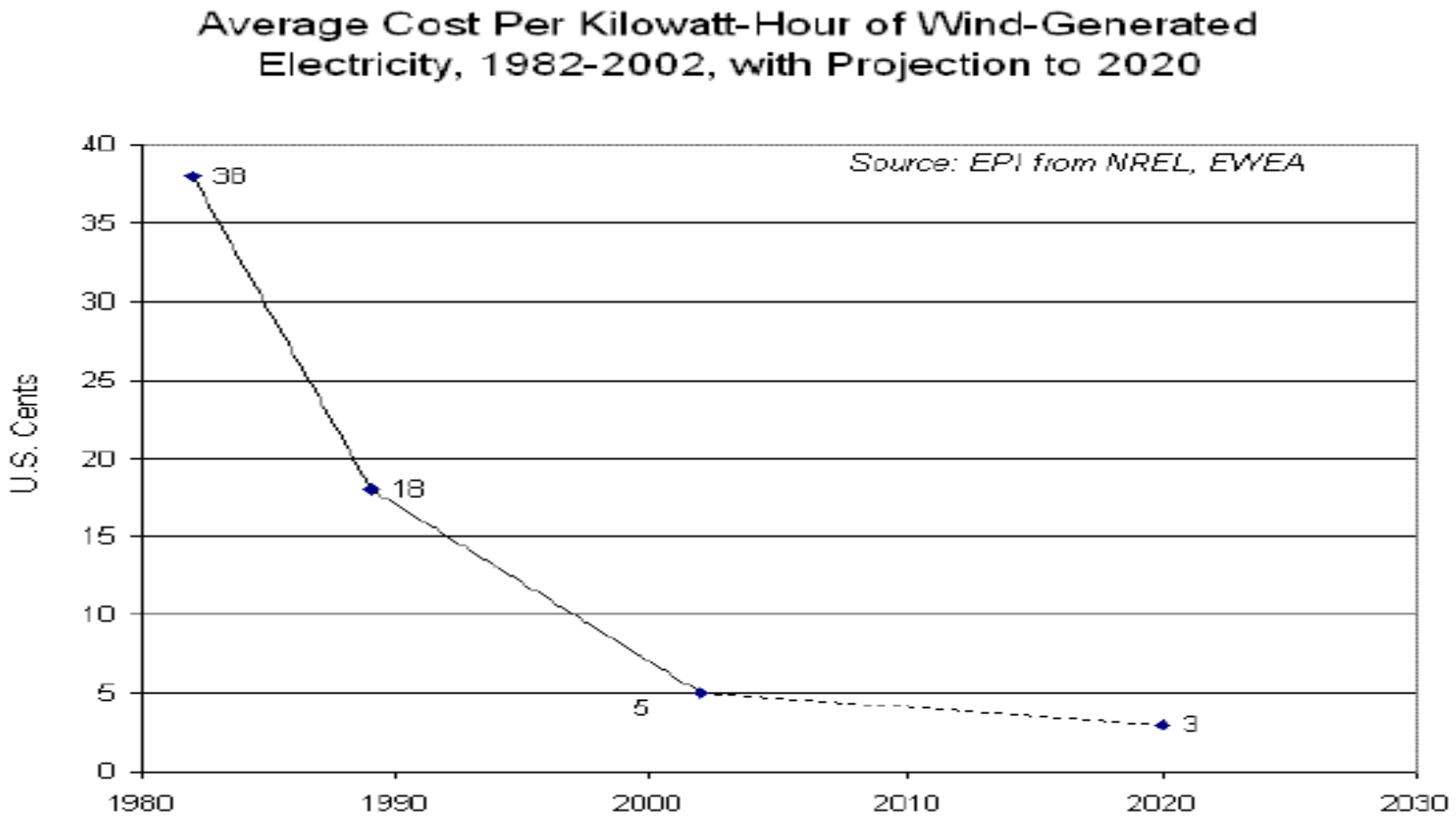
Major country status



Status of US


U.S. Wind Electricity-Generating Capacity, 1980-2005
Megawatts
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1980
1985
1990
1995
2000
2005
2010
Source: GWEC, Worldwatch

Average Cost



Application of Wind Energy

The following table shows some applications of wind energy, who uses it and how wind energy is obtained.

What is wind energy used for?	Who uses wind energy?	How is wind energy obtained?
Using wind to generate electricity	• National and Provincial networks • Communities • Homes and farms • Process industries • Remote communities	The wind powers a wind turbine that produces electricity.
Using wind to pump water	• Farms	The wind powers a wind pump that pumps water.

Cost

The costs of wind energy

The cost of wind energy is determined by:

- the initial cost of the wind turbine installation
- the interest rate on the money invested
- the amount of energy produced

Any wind turbine that is installed in a very windy area generates less expensive electricity than the same unit installed in a less windy area. So it's important to assess the wind at the potential site.

Cost

Modern wind turbine generators cost between $1500 and $2000 per kilowatt for wind farms that use multiple-unit arrays of large machines. Smaller individual units cost up to $3000 per kilowatt. In good wind areas, the costs of generating electricity range between five and ten cents per kilowatt hour. That cost is somewhat higher than the costs associated with an electrical facility, but wind energy costs are decreasing every year, whereas most conventional generation costs continue to increase.

In remote areas, generating electricity with diesel generators can range from $0.25 to $1.00 per kilowatt hour. So in good wind areas, electricity that is generated by the wind is clearly cost effective. When compared to the money that is charged by electrical companies, wind energy costs are nearly competitive. And that is without accounting for the environmental and health benefits of using a non-polluting source of energy.

Benefit

The benefits of wind energy

- Wind energy is an ideal renewable energy because:

    1. it is a pollution-free, infinitely sustainable form of energy
    2. it doesn't require fuel
    3. it doesn't create greenhouse gasses
    4. it doesn't produce toxic or radioactive waste.

- Wind energy is quiet and does not present any significant hazard to birds or other wildlife.
- When large arrays of wind turbines are installed on farmland, only about 2% of the land area is required for the wind turbines. The rest is available for farming, livestock, and other uses.
- Landowners often receive payment for the use of their land, which enhances their income and increases the value of the land.
- Ownership of wind turbine generators by individuals and the community allows people to participate directly in the preservation of our environment.
- Each megawatt-hour of electricity that is generated by wind energy helps to reduce the 0.8 to 0.9 tonnes of greenhouse gas emissions that

Advantages

- Renewable source of energy
- Available in everywhere
- Eco-friendly and does not pollute atmosphere unlike the case of generation from coal, oil etc.
- Wind farms occupies a large land area, it is possible to use this land for other purposes like tourist park.

Disadvantages

- Non steady and unreliable
- Wind farms require flat, vacant land and free from forest.
- Fluctuations in electric power depending on fluctuating wind speed.
- Noise, impact on wild life etc.

Thank You !!